Integrated potassium management through composted straws and inorganic fertilizer in maize

Muqarrab Ali[1], Imran Khan[2]*, Muhammad Tahir[2], Athar Mahmood[1], Ather Nadeem[2], Umair Ashraf[3], Ammar Matloob[1]

[1]Department of Agronomy, Muhammad Nawaz Shareef University of Agriculture, Multan, Pakistan
[2]Department of Agronomy, University of agriculture, Faisalabad-38040, Pakistan
[3]Department of Crop Science & Technology, College of Agriculture, South China Agricultural University, Guangzhou, China
*Corresponding author: E-mail: drimran@uaf.edu.pk

Abstract

Using organic and inorganic fertilizers concurrently may not only quench the crop nutritive demands but also been proved an eco-friendly nutrient source. In order to evaluate the effect of potassium (K) application from only inorganic, integrated organic and inorganic sources of fertilizers on maize, a field study was conducted during 2008 and 2009 following randomized complete block design (RCBD) with three replications at Agronomic Research Area, University of Agriculture, Faisalabad , Pakistan. In this study composted wheat and rice straws were integrated with the sulphate of potash (SOP) as K source. Regarding application of K from the integrated sources, treatment containing 25% composted rice straw + 75% SOP provided highest leaf area index (LAI; 5.13 and 5.11), eaf area duration (LAD; 217.33 and 219.65 days), crop growth rate (CGR; 28.94 and 29.08 g m^{-2} d^{-1}), total dry matter (TDM; 1,925.03 and1,931.32 g m^{-2}), and gave prominent plant height (215.50 and 218.63 cm), 1,000-grain weight (262.87 and 266.63 g), grain yield (7.02 and 7.38 t ha^{-1}), biological yield (16.63 and 17.37 t ha^{-1}) and harvest index (42.22 and 42.49%) during both the years (2008-09), respectively. Moreover, given years, the integrated use of 25% composted rice straw + 75% SOP earned maximum benefit cost ratio of 2.12 and Rs. 2.22, respectively. Conclusively, integrated use of organic amendments of K with inorganic source might be a better technique over separate application of inorganic source.

Keywords: compost, inorganic fertilizer, potassium, growth, yield, maize.

Introduction

Maize (*Zea mays* L) is the third important cereal crop of Pakistan, after wheat and rice. It is sown on an area of 1,117 thousand hectares with total annual production of 4,527 thousand tons, about 7% more than the last year (GOP, 2013-14). The increased use of maize in industry has given a well-known place to maize in agro-based industries. Despite of higher yield potential, average yield of maize in Pakistan is less than that of developed countries of the world. Thus, there is a need to formulate a site specific agro-technology to enhance maize production (Anjum et al, 2014). Therefore, improvement in the essential-components of existing maize production technology in the country is interesting need of the hour.

Among different agro-management practices nutrient management is of special significance to apprehend maximum potential of maize (Hussain et al, 2006; Ahmad et al, 2008). Although research has brought forth many factors controlling growth, grain yield and quality of maize, nevertheless, the information on the influence of agronomic inputs is still insufficient and requires special attention by the breeders and agronomists. There is general stagnation in crop yields especially in intensive cropping system due to imbalanced use of fertilizers and continuous growing of exhaustive crops which results in nutrient scarcity in growing medium. Overall fertilizer use in Pakistan is quite low and it desires to be intensified to reach the level of advanced countries. Surveys regarding soil fertility have revealed wide-spread deficiency of essential nutrients like N, P and K. According to IPI-OUAT-IPNI Intern Symposium (2009), balanced fertilization is the prime aspect of fertilizer management because well fertilizer plants can withstand biotic and abiotic stresses in a better way.

Potassium is the third major plant nutrient. It is the primary cation found in plants. Its importance for maize has increased with the cultivation of hybrid varieties and intensive agriculture. Modern maize hybrids show differential response to its absorption, translocation, and utilization in plants (Minjian et al, 2007). Although it is not incorporated into any specific tissue yet it serves several vital functions in plant growth and is required in large quantities by maize. Neutralization of organic acids, formed during metabolism, enzyme activation, regulating leaf stomatal movement, and facilitating of photosynthates translocation are the tasks of K in plants (Pettigrew, 2008). The K status of Pakistani soils are decreasing with alarming rates and the per acre utilization of K for crop production is also far lesser than other countries

 RECEIVED 16/16/2015

(Bukhsh et al, 2010). Bukhsh et al (2011) reported the positive effect of increasing K fertilization on growth, development and grain yield in hybrid maize.

Organic amendments are always have a long term impacts on soil and improves its health (Zamir et al, 2014). Composting is an eco-friendly approach to dispose off the organic waste and then addition in the soil as soil amendment. A well decomposed organic waste has high nutrient value, narrow C:N ratio, and free from undesired features (Zia et al, 2003). However, its nutritive value can further be improved by blending synthetic fertilizers with finished compost but inappropriate ratio between compost material and chemical fertilizer may deteriorate its quality and imparts its organic characteristics.

Keeping in view the importance of K as the major plant nutrient and economical uses of compost the present study was designed with the objective to evaluate the different combinations of organic (wheat and rice straw compost) and inorganic (sulphate of potash) sources of potassium at constant levels of nitrogen and phosphorous for increased growth and yield of maize.

Materials and Methods

The study was carried out at Agronomic Research Area, University of Agriculture, Faisalabad, Pakistan, during the year 2008 and 2009. The experimental design was laid out by following the Randomized Complete Block Design (RCBD) with three replications. Physio-chemical analysis of soil of the experimental area was done before sowing and after harvesting the crop. The analysis revealed that the soil have pH 8.1, EC 1.9 dS m^{-1}, Organic matter 0.56 %, total nitrogen 0.02%, available P 6.1 ppm and available K 118 ppm. Moreover, the soil texture was sandy clay loam in nature. Pressmud (PM), poultry manure (PoM) and composted straws were analyzed for their various chemical properties in laboratory (Table 1).

Composting and N, P, K determination

In this study, effective micro-organisms (EM) based quick compost production system (Hiraoka, 2002) was used for rice and wheat straw compost production. One pit of 6 ft length, 4 ft width 3 ft depth each for rice and wheat straw enclosed by concrete walls. Raw material used each for rice and wheat straw compost production consisted of three portions of rice straw and wheat straw respectively, two portions of cow dung and effective micro-organism solution. All ingredients were mixed except accelerator. Then the ingredients were mixed to heap up a 0.5 ft layer of mixture in the pit and accelerator sprinkled over it. This process repeated until pit was filled. The pit was covered with plastic sheet. The whole mixture of compost was mixed after every two weeks for rapid aerobic decomposition. The compost was ready to use after couple of weeks later which were packed in plastic bags having 30 kg weight. The compost produced through this process was air dried, sieved and then stored for use in field experiments. A separate prepared compost samples was oven dried and examined for various chemical characteristics (Table 1).

After digestion, Kjeldhal method was used to determine the nitrogen contents. For phosphorus, in an acid mixture of HNO_3 and $HClO_4$, samples were digested. Then phosphorus was determined by developing colour, using colour reagent (ammonium molybdate, ammonium vanadate and nitric acid) with a spectrophotometer ANA-730 at 470 nm wavelength after calibrating with P standards (Handbook 60, Method 61: p.134). Whereas; Corning flame photometer was used to access the amount of potassium after calibrating the instrument with K standards (Handbook 60, Method 58a:p. 132).

Treatments: T1: Control (without K); T2: 100% K from inorganic source; T3: 75% K from organic source (Composted R.S*) + 25% K from inorganic source; T4: 50% K from organic source (Composted R.S*) + 50% K from inorganic source; T5: 25% K from organic source (Composted R.S*) + 75% K from inorganic source; T6: 75% K from organic source (Composted W.S**) + 25% K from inorganic source; T7: 50% K from organic source (Composted W.S**) + 50% K from inorganic source; T8: 25% K from organic source (Composted W.S**) +75% K from inorganic source (R.S*= Rice straw; W.S**= Wheat straw)

Crop husbandry

Maize hybrid FH-810 was sown on a well-prepared seedbed in August 2008 and 2009. Seedbed was prepared by 2-3 times cultivation the soil with tractor mounted cultivator each followed by planking. The crop was sown with the help of dibbler by maintaining row to row distance of 75 cm and plant to plant distance of 20 cm. In the both studies the seed rate of 20 kg ha^{-1} was used to obtain an optimum plant population. Nitrogen (N) in the form of urea and Phosphorus

Table 1 - Analysis of different organic materials used in the studies.

Determinations	Unit	Composted wheat straw	Composted rice straw
pH	-	7.34	7.11
EC	dS m^{-1}	6.17	6.31
Organic matter	%	48.45	46.76
Organic carbon	%	27.92	27.04
Total nitrogen	%	0.69	0.92
Available Phosphorus	g kg^{-1}	0.12	0.65
Potassium	g kg^{-1}	1.38	1.56

(P) in the form of single super phosphate (SSP) was applied at the rate of 296 and 167 kg ha^{-1}, respectively. The entire of phosphorus, potassium and one third quantity of total N was applied at the time of sowing while remaining N was top dressed in two equal splits at knee height stage and at flowering stage in both the years. For K, organic and inorganic sources were used in different ratios as per treatments. The organic sources for P were poultry manure and press mud while the inorganic source was single super phosphate (SSP). For K the composted wheat straw and rice straw were used as organic sources while inorganic source was sulphate of potash (SOP) that was applied at the rate of 125kg ha^{-1}, as basal dose. The nutrient composition obtained from different components in each treatment is given in Table 2.

Each year, maize was harvested manually, in the second week of November. After harvesting, the plants were left in the field for two days for sun drying, and thereafter tied in bundles and stalked for four weeks. Then the cobs were separated from the stalks and dried under the sun for twenty days prior to shelling. Crop growth, development, maize phenology, growth and yield were measured by using standard procedures.

Statistical and Economic analysis

All the data were analyzed by using the analysis of variance technique and difference among treatments means were compared by the least significant difference (LSD) test at 0.05 probability (Steel et al, 1997). Economic analysis was conducted to look into comparative benefits of different agronomic practices used in this study. Marginal analysis was carried out according to procedures devised by CYMMIT (1998).

Results

Growth was analyzed by evaluating the effect of integrated potassium management on leaf area index (LAI), leaf area duration (LAD), crop growth rate (CGR) and total dry matter (TDM). Application of both organic and inorganic K sources had significant effect ($P < 0.05$) on LAI of maize crop. In both years, 25% K from organic source (Composted Rice Straw) +75% K from inorganic source treatment gave significantly higher LAI than all other treatments in either year (Table 3). The effect of treatments on cumulative leaf area duration (LAD) indicated that all the treatments under study produced significantly higher LAD than control (Table 3). The 25% K from organic source (Composted Rice Straw) + 75% K from inorganic source treatment was highly effective as it enhanced LAD compared to other treatments in both experimental years. Data showed that 25% K from organic source (Composted Rice Straw) + 75% K from inorganic source produced considerably higher CGR over all other treatments in both years (Table 3). However, comparable values had been achieved with T5 (25% K from organic source (Composted Rice Straw) + 75% K from inorganic source), T2 (100% K from inorganic source (recommended dose), and T8 (25% K from organic source (Composted Wheat Straw) + 75% K from inorganic source) treatments regarding CGR. Minimum CGR was recorded in control treatment as compared to all other treatments.

Significant differences in total dry matter (TDM) accumulation among treatments were found in both years (Table 3). In all treatments, TDM production increased steadily after crop establishment until maturity. The treatment where 25% K from organic source (Composted Rice Straw) + 75% K from inorganic source was applied significantly increased TDM compared to other treatments, except treatment where 100% K from inorganic source and treatment where 25% K from organic source (Composted Wheat Straw) + 75% K from inorganic source was applied and for these treatments the differences in final TDM were statistically at par with each other. The minimum TDM production was given by control treatment where no potassium was added in both years.

Integrated potassium management treatments considerably affected the plant height at harvest (Table 4). In both years significant differences in plant height among various composted treatments were found. The treatment where 25% K from organic source (Composted Rice Straw) + 75% K from inorganic source gave the maximum plant height (215.50 and 218.63 cm in 2008 and 2009, respectively) compared to all other treatments in either year that was comparable with T8 (25% K from organic

Table 2 - Nutrient contents applied during the study through different organic and inorganic sources.

Treatments	Compost used kg ha^{-1}	N kg ha^{-1}	P kg ha^{-1}	K kg ha^{-1}
T1= Control (without K)	-	296	167	-
T2= Recommended dose	-	296	167	125
T3= (75% Composted RS+25% SOP)	9000	259.9	159.3	30.75
T4= (50% Composted RS+50% SOP)	6000	271.4	161.1	61.75
T5= (25% Composted RS+75% SOP)	3000	285.2	162.9	92.5
T6= (75% CompostedWS+25% SOP)	11200	259.9	151.2	30.75
T7= (50% Composted WS+50% SOP)	7500	271.4	155.7	61.92
T8= (25% Composted WS+75% SOP)	3750	285.2	160.2	92.5

RS= Rice straw; WS= Wheat straw;T1: Control (without K); T2: 100% K from inorganic source; T3: 75% K from organic source (Composted RS*) +25% K from inorganic source; T4: 50% K from organic source (Composted RS*) +50% K from inorganic source; T5: 25% K from organic source (Composted RS*) +75% K from inorganic source; T6: 75% K from organic source.

Table 3 - Effect of integrated potassium management through composted straws and inorganic fertilizer on maize growth parameters.

	2008				2009			
	LAI	LAD (days)	CGR ($g\ m^{-2}\ d^{-1}$)	TDM ($g\ m^{-2}$)	LAI	LAD (days)	CGR ($g\ m^{-2}\ d^{-1}$)	TDM ($g\ m^{-2}$)
Treatments								
T1	4.02 c	174.38 f	22.54 d	1485.55 f	3.89 c	170.08 e	22.60 e	1493.65 e
T2	4.79 ab	205.78 bc	27.52 ab	1827.77 abc	4.93 ab	208.23 b	27.72 abc	1843.69 ab
T3	4.65 b	191.05 de	25.82 c	1696.23 de	4.67 b	192.00 cd	26.02 d	1708.51 cd
T4	4.80 ab	200.53 bcd	26.88 bc	1772.17 bcd	4.90 ab	203.93 b	27.09 bcd	1789.44 bc
T5	5.13 a	217.33 a	28.94 a	1925.03 a	5.11 a	219.65 a	29.08 a	1931.32 a
T6	4.61 b	188.58 e	25.29 c	1666.62 e	4.60 b	186.28 d	25.54 d	1683.60 d
T7	4.78 ab	198.05 cde	26.77 bc	1762.37 cde	4.91 ab	201.83 bc	26.62 cd	1755.51 bcd
T8	4.96 ab	209.40 ab	28.21 ab	1872.34 ab	4.98 ab	210.10 ab	28.37 ab	1891.15 a
LSD($p \leq 0.05$)	0.4	9.49	1.6	102.46	0.39	11.35	1.64	97.23

Values sharing a letter in common within a column do not differ significantly at $p \leq 0.05$. LAI: Leaf area index, LAD: Leaf area duration, CGR: Crop growth rate, TDM: Total dry matter; T1: Control (without K); T2: 100% K from inorganic source; T3: 75% K from organic source (Composted R.S*) +25% K from inorganic source; T4: 50% K from organic source (Composted R.S*) +50% K from inorganic source; T5: 25% K from organic source (Composted R.S*) +75% K from inorganic source; T6: 75% K from organic source.

source (Composted Wheat Straw) + 75% K from inorganic source), T2 (100% K from inorganic source), T4 (50% K from organic source (Composted Rice Straw) +50% K from inorganic source) and T7 (50% K from organic source (Composted Wheat Straw)+ 50% K from inorganic source). The control treatment exhibited the lowest plant height among treatments.

Moreover, average grain weight was significantly affected by integrated K management treatments during both years (Table 4). The treatment where, 25% K from organic source (Composted Rice Straw) + 75% K from inorganic source was applied resulted in considerable increase in 1,000-grain weight compared to other treatments, while, minimum 1,000-grain weight was recorded in control.

In both years, integrated potassium management showed significant difference in grain yield (Table 4). The treatment where, 25% K from organic source (Composted Rice Straw) +75% K from inorganic source produced higher grain yield than all other treatments. Furthermore, treatment where 100% K from inorganic source was applied was also comparable with T5 (25% K from organic source (Composted Rice Straw) + 75% K from inorganic source) and T8 (25% K from organic source (Composted Wheat Straw) + 75% K from inorganic source) treatments only in 2008 but not with T5 (25% K from organic source (Composted Rice Straw) + 75% K from inorganic source) in 2009. The control treatment produced the lowest grain yield during the both seasons.

Integrated potassium management had also a significant effect on total biomass production, at final harvest. During both years, application of 25% K from organic source (Composted Rice Straw) + 75% K from inorganic source produced highest biomass while minimum biological yield was reaped from control treatment in either year (Table 4).

The data showed that the treatment where 25% K from organic source (Composted Rice Straw) + 75% K from inorganic source was applied gave maximum net income of USD 722.36 ha^{-1}, (2008) and USD 790.23 ha^{-1} (2009) followed by treatment where 100% K from inorganic source (Table 5). Variation existed in benefit-cost ratio (BCR) in both years (2008-09). During both years, the treatment 25% K from organic source (Composted R.S*) + 75% K from inorganic source gave higher BCR, followed by treatment where 100% K from inorganic source was used (Table 5). A small variation in the cost of production in both years was due to variations in market price of various inputs involved in the crop production. The sensitivity analysis was carried out to monitor the effects of increase in prices of inputs by 10% from the current prices (year 2008-09). The significance of benefit cost ratio results remained the same as were on normal prices.

Discussion

In the current study, it was observed that integrated potassium management through different organic and inorganic sources has significant effects on growth and yield of maize. Leaf area index (LAI) is the most important variable as it can be widely modified by manipulating the agronomic practices (Anjum et al, 2014). Indeed a major objective of agronomic practices like nutrient management is to have higher LAI for maximizing interception of radiation for maximum TDM production and grain yield. The increased LAI in T5 (25% K from organic source (Composted Rice Straw) + 75% K from inorganic source) and T8 treatment (25% K from organic source (Composted Wheat Straw) + 75% K from inorganic source) could be attributed to better growth and development of leaves. Similar results were reported by He and Li (2004) and Saha et al (2008) in sugarcane and soybean respectively. In the present study, TDM production differ significantly among different treatments and T5 (25% K from organic source (Composted Rice

Table 4 - Effect of integrated potassium management through composted straws and inorganic fertilizer on maize growth parameters.

	2008					2009				
	Plant height (cm)	1000-grain weight (g)	Grain yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)	Plant height (cm)	1000-grain weight (g)	Grain yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Treatments										
T1	190.27 c	215.10 e	5.13 e	13.28 d	38.62 b	194.30 c	215.13 e	5.01 f	13.02 f	38.49 b
T2	204.83 ab	251.30 abc	6.77 ab	16.17ab	41.88 a	214.10 ab	253.43 ab	6.90 bc	16.46 bc	41.91a
T3	199.37 bc	228.83 d	6.14 cd	15.04 c	40.86 ab	206.93 abc	231.03 cd	6.29 de	15.34 e	40.99 a
T4	203.00 abc	244.27 bc	6.42 bc	15.45 bc	41.59 a	210.70 ab	246.87 b	6.65 cd	15.97 cd	41.64 a
T5	215.50 a	262.87 a	7.02 a	16.63 a	42.22a	218.63 a	266.63 a	7.38 a	17.37 a	42.49 a
T6	197.53 bc	226.80 de	5.98 d	14.81 c	40.38 ab	204.73 bc	225.57 de	6.19 e	15.30 e	40.47 ab
T7	202.03 abc	239.03 cd	6.31cd	15.23 c	41.44 a	208.43 ab	242.73 bc	6.47 de	15.59 de	41.53 a
T8	209.30 ab	252.73 ab	6.79 ab	16.17 ab	41.99 a	216.10 ab	255.93 ab	7.11 ab	16.89 ab	42.12 a
LSD($p \leq 0.05$)	13.72	12.98	0.38	0.92	2.43	13.22	13.68	0.36	0.63	2.25

Values sharing a letter in common within a column do not differ significantly at $p \leq 0.05$; T1: Control (without K); T2: 100% K from inorganic source; T3: 75% K from organic source (Composted R.S*) +25% K from inorganic source; T4: 50% K from organic source (Composted R.S*) +50% K from inorganic source; T5: 25% K from organic source (Composted R.S*) +75% K from inorganic source; T6: 75% K from organic source (Composted W.S**) +25% K from inorganic source; T7: 50% K from organic source (Composted W.S**) +50% K from inorganic source; T8: 25% K from organic source (Composted W.S**) +75% K from inorganic source

Straw) + 75% K from inorganic source) treatment out yielded all other treatments. All these results emphasized that compost addition to soil increase yield by enhancing chlorophyll content and leaf N concentration, and consequently boosted photosynthetic activities and ultimately enhanced the maize yield (Amujoyegbe et al, 2007). Despite high availability of nitrogen to plants, in K limiting environment, the assimilation of nitrogen is reduced. More availability of K enhanced the utilization (assimilation) of nitrogen into plant biomass. In both the years, variations in TDM or grain yield caused by different treatments were also positively related with the cumulative LAD, a result similar to that reported in study one.

In both years, integrated potassium (K) management showed significant effects on grain yield and T5 (25% composted rice straw + 75% SOP) out yielded all other treatments. Similar results were reported by Ondieki et al (2011) in African nightshades. The factors which have direct effect on the grain yield are the better leaf area, CGR and also prolonged LAD. Dry matter production plant^{-1} and its accumulation with various plant parts has an indirect effect on grain yield through the yield components, which in turn depended on different growth functions viz., plant height, leaf area index and leaf area duration. Significant decrease in grain and TDM yield of maize due to the application of different rates of organic sources of fertilizer might be attributed to slow release and low content of nutrients.

Results showed that T5 (25% K from organic source (Composted Rice Straw) + 75% K from inorganic source) gave the maximum plant height and 1000-grain weight as compared to all other treatments in both the years. Moreover, Zamir et al (2014) also recorded an improved grain yield in maize where maize straws were incorporated as organic mulch. In the present study, combined use of mineral and organic fertilizer such as composted crop residues improved soil chemical and physical conditions. In this regard, T5 (25% K from organic source (Composted Rice Straw) + 75% K from inorganic source) treatment enhanced growth and yield and related attributes compared to other treatment combination. Similar results were reported by Abdelhamid et al (2004) working on faba bean crops. Many researchers observed higher yield components in maize due to the integrated use of compost and chemical fertil-

Table 5 - Effect of different sources of K on net income and benefit cost ratio (BCR) during 2008-09.

	2008				2009			
	Total expenditure (USD ha^{-1})	Gross income (USD ha^{-1})	Net income (USD ha^{-1})	BCR	Total expenditure (USD ha^{-1})	Gross income (USD ha^{-1})	Net income (USD ha^{-1})	BCR
T1	528.25	998.54	470.29	1.89	528.25	975.18	446.93	1.85
T2	638.70	1317.76	679.07	2.06	638.70	1345.01	706.32	2.11
T3	648.01	1195.13	547.12	1.84	651.78	1224.33	572.55	1.88
T4	644.73	1249.64	604.91	1.94	648.67	1294.40	645.73	1.99
T5	642.12	1364.48	722.36	2.12	646.27	1436.50	790.23	2.22
T6	800.92	1163.99	363.07	1.45	804.69	1204.87	400.18	1.49
T7	746.58	1228.22	481.64	1.64	750.52	1261.31	510.79	1.68
T8	692.87	1319.71	626.84	1.90	696.99	1383.94	686.95	1.99

Values sharing a letter in common within a column do not differ significantly at $p \leq 0.05$. LAI: Leaf area index, LAD: Leaf area duration, CGR: Crop growth rate, TDM: Total dry matter; T1: Control (without K); T2: 100% K from inorganic source; T3: 75% K from organic source (Composted R.S*) +25% K from inorganic source; T4: 50% K from organic source (Composted R.S*) +50% K from inorganic source; T5: 25% K from organic source (Composted R.S*) +75% K from inorganic source; T6: 75% K from organic source.

izers (Shui et al, 2007; Haghighi et al, 2010).

Economic analysis showed that T5 (25% K from organic source (Composted Rice Straw) + 75% K from inorganic source) gave higher net return compared to other organic treatments. Maximum benefit cost ratio of 2.25 in 2008 and 2.35 in 2009 was obtained in T5 and it was probably due to low cost of cultivation in 2008. Increased in yield components with treatment T5 (25% K from organic source (Composted Rice Straw) + 75% K from inorganic source) might enhance the nutrient concentration in the rhizosphere resulted in better uptake of assimilates and low K potassium fixation due to presence of more ions owing to the application of rice straw compost along with mineral fertilizer. Due to this reason, benefit cost ratio was higher in this treatment along with all other components. Similar results were also reported by Mucheru et al (2007).

Sensitivity analysis showed that the significance of net income and benefit cost ratio remained same when we increased input prices 10% from current prices. It is cleared that net benefits and cost benefit ratio remained in similar trend in T5 treatment where 25% composted rice straw + 75% SOP. Integrated use of 25% composted rice straw + 75% SOP for maize crop was beneficial and gave more net benefits compared to all other integrated treatment combinations, even when input prices were increased by 10%.

Conclusion

The results of the study indicated that combination of 25% composted rice straw and 75% SOP was best option for integrated K management and thus enhanced crop growth and development, grain yield and net income. Overall treatment wise economic benefit was: T5 > T2 > T4 > T8 > T1 > T3 > T7 > T6 which confirmed that organic manures (25%) along with adequate proportion of synthetic fertilizer (75%) could be helpful in increasing stagnant grain yield of maize on sustainable basis and maximize profitability.

References

Abdelhamid MT, Horiuchi T, Oba S, 2004. Composting of rice straw with oilseed rape cake and poultry manure and its effects on faba bean (*Vicia faba* L.) growth and soil properties. J Biores Tech 93:183-189

Ahmad RM, Naveed M, Aslam ZA, Arshad M, 2008. Economizing the use of nitrogen fertilizer in wheat production through enriched compost. Rev Agri Food Sys 23: 243-249

Amujoyegbe BJ, Opabode JT, Olayinka A, 2007. Effect of organic and inorganic fertilizer on yield and chlorophyll content of maize (*Zea mays* L.) and sorghum (*Sorghum bicolor* L.) Moench). African J Biotech 6 (16): 1869-1873

Anjum SA, Ehsanullah, Ashraf U, Tanveer M, Qamar R, Khan I, 2014. Morphological and phenological attributes of maize affected by different tillage practices and varied sowing methods. American J Plant Sci 5: 1657-1664

Bukhsh MAAHA, 2010. Production potential of three maize hybrids as influenced by varying plant density and potassium application, PhD dissertation, Department of Agronomy, University of Agriculture, Faisalabad, Pakistan

CYMMIT, 1998. From agronomic data to farmers recommendations: an economic training manual. Completely revised edition. Mexico

GOP (Government of Pakistan), 2014. Economic survey of Pakistan 2013-14, pp. 17-23. Ministry of Food, Agric and Livestock Division (Economic Wing). Islamabad

Haghighi BJ, Yarmahmodi Z, Alizadeh O, 2010. Evaluation the effects of biological fertilizer on physiological characteristic and yield and its components of corn (*Zea mays* L.) under drought stress. American J Agriculture and Biological Sci 5: 193-198

He Y, Li R, 2004. Effect of the organo–inorgano-mixed fertilizer application on sugarcane yield and soil enzymatic activity. Sugar Crops China 4: 36-38

Hiraoka H, 2002. Biofertilizer production plant, Myanmar, FAO/UNDP Project

IPI-OUAT-IPNI Intern Symposium (2009). Potasium, pp. 5-7. In: Role and benefits in improving nutrient management for food production, quality and reduced environ-mental damage. Brar MS ed. Symposium procedings, Orisa University of Agriculture and Technology, Bhubaneswar

Minjian C, Haiqui Y, Hongkui Y, Chungi J, 2007. Difference in tolerance to potassium deficiency between maize inbred lines. Plant Prod Sci 10(1): 42-46

Hussainm MZ, Rehmanm N, Khan MA, Roohullah, Ahmed SR, 2006. Micronutrients status of Bannu basen soils. Sarhad J Agri 22: 283-285

Mucheru M, Mugendi D, Kung'u JB, Mugwe J, Bationo A, 2007. Effects of organic and mineral fertilizer inputs on maize yield and soil chemical properties in a maize cropping system in Meru South District Kenya. Agroforestry Systems 69: 189-197

Nishanth D, Biswas DR, 2008, Kinetics of phosphorus and potassium release from rook phosphate and waste mica enriched compost and their effect on yield and nutrient uptake by wheat (*Triticum aestivum* L.). Biores Tech 99: 3342-3353

Ondieki MJ, Aguyoh JN, Opiyo AM, 2011. Fortified compost manure improves yield and growth of African nightshades. I J E M S 2(2): 231-237

Pettigrew WT, 2008. Potassium influences on yield and quality production for maize, wheat, soybean and cotton. Physiol Plant 133: 670–681.

Rengel Z, Damon MP, 2008, Crops and genotypes differ in efficiency of potassium uptake and use. Physiol Plant 133: 624-636

Ruiz J, Romero L, 2002. Relationship between potassium fertilization and nitrate assimilation in leaves

and fruits of cucumber (*Cucumis sativus*) plants. Ann Appl Biol 140: 241-245
Saha S, Prakash V, Kundu S, Kumar N, Mina BL, 2008. Soil enzymatic activity as affected by long-term application of farmyard manure and mineral fertilizer under a rain fed soybean–wheat system in N-W Himalaya. Eur J Soil Biol 44: 309-315
Shui DT, Yun J, Shaowen H, Tian LS, Ping HE, 2007. Effect of long term application of K fertilizer and wheat straw to soil on crop yield and soil K under different planting systems. Agri Sci China 6: 200-207
Zamir SI, Asif M, Haq I, Ashraf U, Hussain S, Khan MK, 2014. Maize phenology, yield and its quality is affected by organic mulches and various irrigation regimes. Int J Modern Agri 3(2): 56-59
Zia MS, Khalil S, Aslam M, Hussain F, 2003. Preparation of compost and its use for crop production. Sci Tech Develop 22: 32-44